WHEELS OF SINGLE COMPONENT CONSTRUCTION AND METHOD OF MAKING SAME

FIELD OF INVENTION

[0001] This invention generally relates to wheels and particularly to wheels used with vehicles. In particular this invention relates to steel wheels and, more particularly, to steel wheels having approximately 5° and 15° drop center rims. Such wheels may be used with any type of vehicle, including but not limited to commercial vehicles. This invention further relates to a method of manufacturing the wheel of this invention.

BACKGROUND OF THE INVENTION

[0002] Specifications for wheels having approximately 5° or 15° taper and profile (where tire contact is involved) drop center rims are generally set forth in international tire and rim standards, manuals, and handbooks such as ETRTO, T&RA and JATMA. These specifications are generally applicable for all types of 5° or 15° drop center rims, as well as other types of wheels. 15° drop center rims are typically used for tubeless tire applications, while 5° drop center rims are generally used for both tube and tubeless applications. Removable flanges are not required for wheels having 5° or 15° drop center rims.

[0003] Typically, a fabricated sheet steel wheel having a 5° or 15° drop center rim for a vehicle are fabricated from more than one component. For example, the inner periphery of a separate rim component may be welded or otherwise affixed to a separate central disc component also made of sheet steel. The tire mounts on the outer periphery of the rim supported by the central disc provides a means for attaching to spindle hubs the brake drum or other associated parts of the vehicle. With such wheel construction

it is important that the rim and disc, in their assembled relationship, insure (within acceptable tolerances) roundness of the rim and accurate axial alignment of the rim with respect to the disc. Deviations in the roundness of the rim and axial alignment are referred to as "radial" and "axial" run-outs, respectively. In this regard, vehicle manufacturers establish extremely rigid tolerances and run out specifications.

[0004] When wheels are manufactured by conventional methods, the rim and discs are normally manufactured as separate components. These two components are then assembled together. The disc is fixed at its outer peripheral flange to the inner periphery of the rim by welding (or other appropriate method) to form the complete wheel assembly. When utilizing the conventional method of making the rims by using a butt-welded hoop made out of a strip of hot rolled steel sections or plate, maintaining acceptable tolerances on the roundness of the rim hoop is extremely difficult due to the localized "kink" in the region of the butt welded joint and the non-uniform spring back during the rim diameter calibration operation. Furthermore, substantial distortion encountered during the welding of the disc and rim requires costly additional corrective steps in the manufacturing process to ensure that the axial alignment between the rim and the disc is held within acceptable limits. Once such distortion has occurred, it generally cannot be completely corrected. A shift in the axial alignment and the localized kink in the rim in the region of the butt welded joint is known to produce first harmonics while the vehicle is running, thus causing vibration and high noise. The axial shift between the disc and the rim also produces imbalance of the wheel causing vehicle disturbance, thumping, vibration and shaking.

[0005] Further, when conventional wheels have been run with test overloads to induce failure, fatigue and cracks have often occurred in the center of the disc where the disc is attached to its supporting axle, and in the welds which attach the rim to the disc.

[0006] Moreover, a welded wheel assembly does not perform well under the rigors of the balancing and centering of the wheel. In addition, conventional butt-welded rim hoop joints do not always provide the airtight construction necessary for mounting tubeless tires. Welded joints also constitute a weak point in the wheel, which limits the useful life of the wheel.

[0007] In addition, it is well recognized that wheels are not only critical to safety in the use of an automotive vehicle, but also being an un-sprung mass has a pronounced effect on vehicle stability and driving comfort.

[0008] However, to date, conventional wheel constructions and methods of assembly have not addressed the foregoing issues. Thus, a unitary (also referred herein as "one-piece") wheel construction which comprises rim and disc portions formed from the substantially contiguous single or unitary piece of substrate material, such as steel, and method for making such a wheel would address the deficiencies found in the conventional wheel construction described above. Additionally, a unitary wheel rim and disc assembly comprising low carbon and high strength steel would lead to a reduction in weight and would facilitate balancing and centering of the wheel. Thus, a unitary wheel rim and disc assembly, and particularly wheel assemblies comprising 5^{o} and 15^{o} drop center rims, would provide improved technical and economic benefits inasmuch as the unitary construction lends itself to cost effective

mass production, improved strength, consistency in dimensions and vibration within established tolerances, improvement in the airtight quality of the seal created when tubeless tires are mounted on the wheel, as well as other improved characteristics.

[0009] This application claims the priority of both Indian Patent Application No. 012/CHE/04, entitled A METHOD OF MANUFACTURING INTEGRAL WHEEL RIM AND DISC ASSEMBLY OF A 5° TAPER BEAD-SEAT OF FLAT OR SEMI-DROP CENTER RIM AND INTEGRAL WHEEL CONSTRUCTION, filed on January 7, 2004, and Indian Patent Application No. 013/CHE/04, entitled A METHOD OF MANUFACTURING ONE-PIECE WHEEL OF A 5° & 15° DROP CENTER RIMS AND THE ONE-PIECE WHEEL CONSTRUCTION, filed on January 7, 2004, the entire disclosures of which are hereby incorporated by reference as if being set forth in their respective entireties herein.

SUMMARY OF THE INVENTION

[00010] The present invention relates to a steel wheel of substantially unitary construction. The wheel comprises a disc portion and a rim portion substantially contiguous with said disc portion, wherein the wheel is of substantially unitary construction. The invention also relates to an apparatus and method for producing unitary steel wheels. More specifically, the invention relates to a method of manufacturing a steel wheel comprising the steps of forming a disc portion, and forming a rim portion, wherein said rim portion is substantially contiguous with said disc portion and wherein said wheel is of substantially unitary construction.

[00011] In one embodiment of the invention, the unitary steel wheel of this invention further comprises a wheel having approximately 5° and 15° drop center rims. This construction lends itself particularly well

to mass production and provides wheels which meet the requirements enumerated above. A unitary wheel rim and disc assembly, and particularly an assembly which includes a 5° and 15° drop center rims, requires less material to construct and is substantially simpler to fabricate as there are no parts to assemble and no welding or other steps required to align or affix separate components. However, in some embodiments of this invention, it may be desirable to incorporate some assembled components requiring alignment or affixation. Regardless of the embodiment constructed, however, cost savings are realized with the method for making the wheel of the invention hereof.

[00012] Turning now to an embodiment of the invention which comprises a unitary wheel comprising a rim and disc assembly having a 5° taper bead-seat of flat or semi-drop center rim, the wheel construction consists of a substantially contiguous and typically substantially circular blank formed from steel sheet stock of pre-determined and substantially uniform thickness. The blank preferably has a center hole of predetermined size formed therein or otherwise pierced therethrough. The blank is preformed in a spinning machine to a predetermined profile and cylindrical shape. The performed blank is further spun and flow formed in the spinning machine, wherein the preform is positioned between an outer roller and inner mandrel and held against a clamping plate. The inner mandrel comprises an outboard surface which conforms to the predetermined inner diameter of the rim, wherein the rim comprises inner and outer tire bead-seats and an outer flange. The outer roller comprises an outboard surface which conforms to the predetermined inner diameter of the inner flange. The preform's peripheral cylindrical portion is then spun against the outboard surface of the inner mandrel and outboard surface of the outer roller to form the predetermined profile of the well, the inner and outer bead-seats,

and inner and outer flanges respectively. The spun rim comprising the predetermined semi-finished well, inner and outer bead-seats, and inner and outer flanges is further processed in a spinning machine in a flow-forming and spinning operation. During this process, the disc portion is centered on the center hole in the spinning machine and clamped against an outer clamping plate. The peripheral portion of the rim is positioned between an inner mandrel and an outer roller. The inner mandrel and outer roller form a surface by which the final profile and shape of the well, inner and outer bead-seats and inner and outer flanges are formed during the spinning and flow forming process.

[00013] One aspect of the present invention is a unique spinning and flow forming method for manufacturing unitary steel wheel rim and disc assemblies for vehicles, and particularly for wheels having 5° and 15° drop center rims. This method comprises backward and forward material displacement through the use of a mandrel that is offset against the axis of rotation of the preform. Generally, a circular steel blank formed from sheet stock of pre-determined uniform thickness is provided. The blank preferably has a center hole of a predetermined size is preferably formed or punched therethrough. The blank is placed in a spinning machine and preformed to a predetermined profile and cylindrical shape. The perform is further spun and flow formed in the spinning machine while the preform is positioned between an outer face plate and inner mandrel while being held against a clamping plate. The inner mandrel comprises an outboard surface, which conforms to the predetermined inner diameter of the rim. The rim portion comprises a well, inner and outer bead-seats and an outer flange. The outer face plate comprises an outboard surface which conforms to the predetermined inner diameter of the inner flange. The cylindrical peripheral portion of the preform is then spun against the outboard

surface of the inner mandrel and outboard surface of the outer roller. This step in the spinning process displaces material in backward and forward directions to shape a predetermined profile and form of the well, inner and outer bead-seats, and inner and outer flanges respectively. The spun rim comprising the predetermined semi-finished well, inner and outer bead seats and inner and outer flanges, is further flow formed and spun in the spinning machine. During this step in the process, the disc portion is centered on the center hole in the spinning machine and clamped against an outer clamping plate. The peripheral portion of the rim is positioned between an inner mandrel and outer shaping rollers. The inner mandrel and outer shaping rollers form an outboard surface which conforms to and forms the final shape of the well, inner and outer bead seats, and the inner and outer flanges.

[00014] In another embodiment of the invention, the preform may be subjected to such operations where the center hole, mounting holes and the vent holes are pierced or otherwise formed in the wheel to a predetermined size, preferably before backward and forward spinning of the preform.

[00015] After the final rim profiling and shaping operation, the center hole, vent hole, and/or the mounting holes may be machined to predetermined dimensions in a multi drilling machine or by other suitable means. In addition, the inner and outer flanges may be machined to achieve a flat or round radius on the crowned edges of the flanges, which is step is preferably performed after the center, vent and/or mounting holes are machined.

[00016] Thus, the present invention provides a unique, low cost method of press forming, spinning and flow forming a unitary, one piece wheel rim and disc assembly, and particularly a vehicle wheel having 5°

and 15° drop center rims. The steel blank is formed from sheet stock and is spun and flow formed in a spinning operation which reduces manufacturing costs over conventional methods. The spinning and flow forming technique of this invention employs tools having simple forming surfaces, which minimizes their associated manufacturing cost, as well as repair expenses. The spin forming machine can be easily programmed to form different shapes, such that the present method is especially suited for making specialty and/or low volume wheel designs as well as one-piece type vehicle wheels for bulk manufacturing.

[00017] These and other advantages of the invention will be further understood and appreciated by those skilled in the art by reference to this written specification, as well as the claims and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[00018] The invention will become more readily apparent from the following description of the preferred embodiments therein shown by way of example only, in the accompanying drawings where like numerals designate corresponding parts and features in the various views wherein:

[00019] Figure 1 – shows a sectional view of a steel disc blank having a center hole used in constructing the disc component of welded wheels having 5° and 15° drop center rims of the prior art.

[00020] Figure 2 - shows a sectional view of a spin and flow formed steel disc component used in constructing welded wheels having 5° and 15° drop center rims of the prior art.

[00021] Figure 3 – shows a sectional view of a finished disc component having central, mounting and vent holes used in constructing welded wheels having 5° and 15° drop center rims of the prior art.

[00022] Figure 4 – shows a sectional schematic representation of the welded hoop formed from flat plate used in constructing the steel rim component for welded wheels having 5° and 15° drop center rims of the prior art.

[00023] Figure 5 - shows a sectional schematic representation of the welded hoop after milling, which hoop is used in constructing the steel rim component for welded wheels having 5° and 15° drop center rims of the prior art.

[00024] Figure 6 - shows a sectional schematic representation of the rolling process used in constructing the steel rim component for welded wheels having 5° and 15° drop center rims of the prior art.

[00025] Figure 7 - shows a sectional schematic representation of the calibration operation used in constructing the steel rim component for welded wheels having 5° and 15° drop center rims of the prior art.

[00026] Figure 8 - shows a sectional schematic representation of the vent hole operation used in constructing the steel rim component for welded wheels having 5° and 15° drop center rims of the prior art.

[00027] Figure 9 – shows a sectional schematic representation of the completed assembly of the prior art wheel having a 5° and 15° drop center rim after the disc and rim components are welded together.

[00028] Figure 10 – shows perspective and sectional views of the one-piece steel wheel having a 5° and 15° drop center rim in accordance with the present invention, the perspective view showing a section removed to view the cross-sectional profile.

[00029] Figure 11 – shows a sectional view of a steel disc blank having a center hole used in constructing one-piece wheels having 5° and 15° drop center rims in accordance with the present invention.

[00030] Figure 12 – shows a schematic sectional representation of the first stage of the spinning process used in forming the disc and rim portions of one-piece wheels having 5° and 15° drop center rims in accordance with the present invention.

[00031] Figure 13 – shows a schematic sectional representation of the spun wheel from the Figure 12, wherein mounting and center holes have been formed in accordance with the present invention.

[00032] Figure 14 - shows a schematic sectional representation of the spun wheel from Figure 13 wherein vent holes have been formed in accordance with the present invention.

[00033] Figure 15 - shows a schematic sectional representation of the second stage of the forward and backward displacement of material during the spinning process which continues the process of forming the disc and rim portions of one-piece wheels having a 5° and 15° drop center rims in accordance with the present invention.

[00034] Figure 16 – shows a schematic sectional representation of the final stage of spinning processes which substantially forms the final profile and shape of the well, the inner and outer bead-seats, and

the inner and outer flanges of one-piece wheels having a 5° and 15° drop center rims in accordance with the present invention.

[00035] Figure 17 – shows a schematic sectional representation of the machining process for providing substantially flat or rounded edges to the inner and outer flange crown edges of Figure 16, in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[00036] Turning now to Figures 1 through 9, the conventional method of manufacturing a steel wheel having 5° and 15° drop center rims is shown. The method requires that the rim and disc are manufactured as single components and then joined together by conventional means such as welding.

[00037] The initial steps involved in the manufacture of a conventional steel wheel comprises forming circular blank of pre-determined thickness, press-forming and piercing the center hole, and particularly the mounting and vent holes as, shown for example in Figure 1, Figure 2 and Figure 3.

[00038] The rim is manufactured either by using a flat plate of uniform thickness or using the profiled hot rolled plate as shown in Figure 4 and Figure 5. In either case the plate is coiled into a hoop, butt-welded, joint trimmed and dressed. In the case of a flat plate, the profile of the rim is achieved using either hot or cold press or spinning operations. The rims are then roll formed and calibrated to the diameter within acceptable out-of roundness (run-out) tolerances as shown in the Figure 6 and Figure 7. The valve hole is then finished and the valve installed in the steel rim component of the welded wheel construction as shown in Figure 8.

[00039] The finished discs and rims are then assembled in a press or a fixture and the joints are welded or joined by other means after assembly as shown in Figure 9. The wheels subsequently undergo machining steps to machine and finish the valve, center, vent and mounting holes.

[00040] In contrast to the construction shown in Figures 1 trough 9, the invention disclosed herein relates to a unitary wheel made of metal, such as steel (such as low carbon steel of HSLA steel composition) or other suitable substrate, as well as the apparatus and method of producing a unitary wheel. The unitary wheel comprises both rim and disc portions. The unitary wheel is constructed from a generally circular steel blank formed from sheet stock of pre-determined, substantially uniform thickness. In addition, the blank preferably has a center hole having a predetermined size. In one embodiment, the rim portion further comprises a drop center rim having approximately 5° or 15° bead seats. In an initial fabrication step, the blank is preformed in a spinning machine to a predetermined profile and shape. In a subsequent step, the preform is further spun in a spinning machine to invoke forward and backward displacement of material which continues the process of forming the disc and rim portions of the wheel and, optionally, an inner flange and/or other portions of the wheel. In this subsequent step, the preform is positioned between one or more outer rollers, an inner mandrel and is held against a clamping plate. The inner mandrel comprises an outboard surface which conforms to the predetermined inner diameter of the rim. One or more outer rollers comprise an outboard surface to extend and further form the rim portion and, optionally, an inner flange or other portions. In yet further subsequent steps, the preform peripheral portion is spun against the outboard surface of an inner mandrel and outboard surface of

one or more outer rollers to substantially form the final profile and shape of the wheel which may include a well portion, inner and outer flanges, inner and outer bead seats, and/or other desired portions. Subsequent process steps, such as machining of particular portions or components, may then be carried out to complete the manufacturing process.

[00041] As we now turn to the embodiment of the invention set forth in Figures 10 through 17, it should be noted that the descriptions set forth herein are made for the purpose of illustrating the general principles of this invention and the embodiments specifically referred to herein are offered as non-limiting embodiments of the invention disclosed herein.

[00042] One embodiment of the unitary wheel of this invention, as well as an embodiment of the method of making the unitary wheel, is set forth in Figures 10 through 17. Turning now to Figure 10, perspective and sectional views of the wheel of this embodiment are shown. The wheel is of one-piece or unitary construction and is formed from a single piece of substrate material, such as steel or other suitable material. The substrate is of substantially uniform thickness and is usually provided as a substantially round disc having a center hole therethrough and located approximately at the center of the disc. The wheel is formed from the substrate disc into the wheel shown, which wheel comprises a disc portion and a rim portion, which rim portion is substantially contiguous with the disc portion.

[00043] The wheel of Figure 10 (with additional views shown in Figures 11 through 17) further comprises inner flange 1 and outer flange 5, each portion of which are formed from the substrate disc and are positioned approximately at opposing ends of the rim portion as

contiguous portions of the wheel. Moreover, inner flange 1 is also positioned approximately in the area near where the disc and the rim portions of the wheel meet, while outer flange 5 is positioned approximately at the outer edge of the rim portion. The rim portion further comprises well 3, inner bead seat 2, and outer bead seat 4, each portions of which are also formed from the substrate disc as contiguous elements of the rim portion. Inner bead seat 2 is approximately positioned between inner flange 1 and well 3, while outer bead seat 4 is approximately positioned between outer flange 5 and well 3. In addition, the wheel of Figure 10 further comprises center hole 6, mounting holes 7, vent holes 8, and valve hole 9. Center hole 6 is positioned approximately in the center of the disc portion of the wheel. Vent holes 8 are approximately positioned near the outer edge of the disc portion and approximately between inner flange 1 and mounting holes 7. Mounting holes 7 are approximately positioned between center hole 6 and vent holes 8. Finally, valve hole 9 is positioned approximately on the outer edge of well 3.

[00044] A method of manufacturing the embodiment of the wheel set forth in Figure 10, is shown in Figures 11 through 17. Figure 11 shows a schematic sectional view of the steel disc substrate having a center hole 6 therethrough prior to forming pursuant to the method of this invention. The blank may be of any size or thickness which permits the wheel to be shaped to the desired dimensions.

[00045] Figure 12 shows the first step of manufacturing one-piece wheels having 5° and 15° drop center rims which comprise spinning and flow forming the steel disc substrate of Figure 11. Preferably, the disc is spun and flow formed into a preformed shape in a CNC 4-axis spinning machine or similar device. More specifically, the preform is held between inner mandrel M1, outer roll F1, and

clamping plate C1. Shaping rollers R1 are mounted on a hydraulically actuated slide of the spinning machine which imparts a rolling pressure on the outer peripheral portion of the preform. The spinning and rolling pressure reduces the thickness of the disc and rim portions while forming the cylindrical shape and profile in the rim portion of the preform in accordance with predefined settings in the spinning machine. The outboard surface of inner mandrel M1 corresponds to the predetermined cylindrical shape and profile of the inner diameter of the rim portion. Furthermore, this step may comprise one or more passes of shaping rollers R1 to produce the desired shape and profile of the preform.

[00046] Figure 13 shows a cross sectional view of central hole 6 and a mounting hole 7, while Figure 14 shows a cross sectional view of central hole 6, a mounting hole 7, and a vent hole 8. In a subsequent step or steps schematically depicted in Figures 13 and 14, each of mounting holes 7 and vent holes 8 are formed into the preform by conventional methods such as by a press or other means.

[00047] Figure 15 shows yet another subsequent step wherein the preform is subjected to forward spinning extends and further forms the rim portion comprising well 3, inner bead seat 2, outer bead seat 4 and outer flange 5 into a cylindrical shape of desired thickness, diameter and width. Also, during forward spinning the rim portion comprising inner flange 1 is spun in such a way that the material is displaced in a backward direction, also to a predetermined thickness, diameter and width.

[00048] More specifically, Figure 15 discloses a subsequent step wherein the preform is spun and flow formed in a CNC 4-axis spinning machine or similar device. The preform is positioned between inner mandrel

M2, shaping mandrel S1 and outer roll F2, and is clamped prior to spinning by clamping plate C2. Shaping rollers R2 are mounted on a hydraulically actuated slide of the spinning machine which imparts a rolling pressure on the outer peripheral portion of the preform. The spinning and rolling pressure further reduces the thickness of the disc and rim portions while forming and extending the cylindrical shape and profile of the rim portion to a desired thickness, diameter and width in accordance with predefined settings in the spinning machine. The outboard surface of inner mandrel M2 corresponds to the predetermined cylindrical shape and profile of the inner diameter of the rim portion, while the outboard surface of shaping mandrel S1 corresponds to the predetermined inner diameter of inner flange 1. Shaping rollers R2 are used for both forward and backward spinning to form the outer surfaces of the rim portion and inner flange 1.

[00049] Figure 16 shows yet another subsequent spinning and forming step which produces substantially the final profile of the disc and rim portions of the wheel. In this step, the preform of Figure 15 is subjected to additional spinning and shaping to form substantially the final profile and shape of well 3, inner bead seat 2, outer bead seat 4, inner flange 1 and outer flange 5 of desired thickness, diameter and width.

[00050] More specifically, Figure 16 discloses a subsequent spinning and forming step wherein the preform of Figure 15 is spun and formed in the spinning machine or similar device. Prior to spinning in this step, the preform is positioned between inner mandrel M3 and outer roll F3, and is clamped by clamping plate C3. The disc portion is positioned in the spinning machine such that the centerline of inner mandrel M3 is slightly offset in relation to the centerline of center hole 6 of the perform. The outboard surface of inner mandrel M3

corresponds to the final profile of well 3, inner bead seat 2 and outer bead seat 4. Shaping rollers R3 are mounted on a hydraulically actuated slide of the spinning machine which impart a rolling pressure on the outer peripheral rim portion of the preform to form well 3, inner bead seat 2 and outer bead seat 4. In addition, shaping rollers R1, R2, R4 and R5 substantially form the final profile and shape of inner and outer flanges 1 and 4, respectively.

[00051] Figure 17 shows a cross section of the profile of the final form and shape of the disc and rim portions after the final rim profiling and shaping operation. More specifically, center hole 6, vent holes 8, mounting holes 7, and/or valve hole 9 may be machined to predetermined dimensions in a multi drilling machine or by other suitable means. In addition, the inner and outer flanges may be machined to a desired final shape, such as for example, flat or round radii on the crowned edges of the flanges. This final machining step is preferably, but not necessarily, performed after center hole 6, vent holes 8, mounting holes 7, and/or valve hole 9 are machined.

[00052] It is to be understood that the invention discussed herewith may assume various alternative embodiments and methods of manufacture. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described herein are merely exemplary embodiments of the inventive concepts defined by the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting.

[00053] Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the

invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be regarded as falling within the scope of the invention as defined by the claims that follow.